DOCUMENT RESUME

ED 141 073 SE 022 488

AUTHOR Gourley, Frank A., Jr.
TITLE Metrics Course Outline and Resources.
INSTITUTION North Carolina State Dept. of Community Colleges, Raleigh.
PUB DATE Sep 76
NOTE 34p.; Contains occasional light type

EDRS PRICE MF-$0.83 HC-$2.06 Plus Postage.
DESCRIPTORS Adult Education; *Community Colleges; *Course Descriptions; Curriculum; Higher Education; *Mathematics Education; Measurement; *Metric System; *Resource Guides; Technical Education

ABSTRACT

This booklet is intended as one resource to be used in teaching the metric system in community colleges and technical institutes or in other types of adult education programs. Beginning with a list of seven objectives, the guide provides a detailed outline for a course organized around these objectives. The seven sections of the course are titled: (1) Orientation to the Metric System; (2) The Metric System; (3) Estimating Metric Quantities (length and mass); (4) Derived Units of Length and Mass; (5) Additional Metric Quantities and Units; (6) Conversion Factors; and (7) Metric Measurements and Metric Equipment. A small amount of instructional material related to each section is provided. A list of suggested resources, organized by topic, completes the booklet. (SD)

****
* Documents acquired by ERIC include many informal unpublished *
* materials not available from other sources. ERIC makes every effort *
* to obtain the best copy available. Nevertheless, items of marginal *
* reproducibility are often encountered and this affects the quality *
* of the microfiche and hardcopy reproductions ERIC makes available *
* via the ERIC Document Reproduction Service (EDRS). EDRS is not *
* responsible for the quality of the original document. Reproductions *
* supplied by EDRS are the best that can be made from the original. *
****

ED141073

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

METRICS

COURSE OUTLINE and RESOURCES

SE 022 488

PROGRAM DEVELOPMENT

NORTH CAROLINA DEPARTMENT OF COMMUNITY COLLEGES

2

METRICS

COURSE OUTLINE AND RESOURCES

September, 1976

Developed by:

Frank A. Gourley, Jr.

PROGRAM DEVELOPMENT
DEPARTMENT OF COMMUNITY COLLEGES
RALEIGH, NORTH CAROLINA 27611

PREFACE

The metric system of measurement will soon come into everyday usage in the United States. Individuals employed in selected occupations or industries using metrics are already familiar with this system. For the majority of individuals, metrics is a new measuring system. This publication was prepared to aid in teaching adults this measuring system.

The materials included in this publication are provided as one resource to be used in teaching metrics in technical institutes and community colleges. The intent is to provide access to information that can be used to support the teaching of metrics in adult extension courses, short courses, orientation sessions, industrial training courses, and/or as a part of existing curriculum courses.

The guide provides a suggested course outline, objectives, brief narrative and suggested supplemental resources that may be used with adult learners. The amount of time available for instruction may determine the content to be taught. For example orientation sessions may use only parts of the outline suggested while special courses may emphasize a particular section and use specialized publications not listed in the resources. Problems and exercises are not provided, but should be adopted from the resources. Types of equipment that may be used in teaching metrics are suggested in the section on Metric Measurements.

Additional materials are available from the agencies and organizations listed and from numerous professional societies. Requests should be directed to the professional societies in the field of interest for further information on materials and services available.

While conversion to metric holds many advantages, the changeover will be neither easy nor quick. It is hoped that this guide will help adults in the State learn a new language. The information provided in this guide should be adapted to meet the needs of the local institution and community.

This guide was developed by Frank A. Gourley, Jr., Assistant Director for Engineering Programs, Program Development Section, Department of Community Colleges. Many useful materials were provided by other individuals with the Department of Community Colleges and the Metric Resource Center, Department of Public Instruction. Content in the narrative outline was adapted from selected sources identified in the Suggested Resources section. Special thanks go to these sources.

CONTENTS

	Page
Introduction	1
Course Outline	3
Narrative Outline	5
Orientation to the Metric System	5
The Metric System	9
Estimating Metric Quantities	12
Derived Units of Length and Mass	14
Additional Metric Quantities and Units	16
Conversion Factors	19
Metric Measurements	21
Suggested Resources	23
All You Will Need To Know About Metric (For Your Everyday Life)	31

INTRODUCTION

The Metrics Course Outline and Resources Manual is designed to support the teaching of metrics to adult learners. It was compiled to provide assistance to instructors developing or modifying courses that include the teaching of metric measurement. Because of the variety of applications this material may have, no course description is suggested. It is recommended that course descriptions be developed if necessary to meet the needs of the individuals and industries being served by the local institution. For curriculum students consideration should be given to integrating metrics into existing courses. This approach can be used to minimize the amount of time spent teaching metrics and provide immediate applications of the metric system to measurements used in the particular occupational field being studied.

The objectives provided are generally stated to suggest a systems approach to teaching metrics that proceeds from an overview to specifics, from everyday usage to laboratory usage, and from simple measurements and units to the more complex. The emphasis suggested is to teach the concepts of metric measurement and estimation. Conversion factors should be introduced after the measuring concepts are established.

An outline of instruction is provided that follows the format of the manual. Equipment items are suggested as a part of the outline. Most of these items should be available in the physics laboratory.

A narrative has been compiled to present a general overview of the metric system of measurement. It is intended as background information to assist the instructor in developing activity oriented sessions on metrics. The section of suggested resources is arranged according to the format of the narrative and course outline to suggest materials that can be used to support major topics.

Additional resources and selected agencies and organizations are listed to encourage the pursuit of additional information, materials, and services that can be used in teaching the metric system. Trade and professional societies are not listed, but should be considered as an excellent source of materials for metrics in occupationally oriented classes.

COURSE OUTLINE

OBJECTIVES:

(1) To provide an orientation to individuals in the everyday use of the metric system of measurement

(2) To help individuals become familiar with common units and terminology used in the metric system

(3) To provide a framework for estimating metric units of measurements using the "immersion" approach

(4) To define derived units of length and mass and to provide experience in estimating these units

(5) To define additional metric quantities and units that might be used in specific occupational fields and to provide experiences in approximating these quantities

(6) To provide conversion factors that give the metric value of English units

(7) To provide experience in using metric measurement equipment in the shop or laboratory

---

SUGGESTED OUTLINE OF INSTRUCTION:

I. Orientation to the Metric System

- A. Why metric
- B. Metric usage in world
- C. Metric usage in industries
- D. Metric usage at home

II. The Metric System

- A. Basic quantities (seven primary)
- B. Basic units of measurement
- C. Metric prefixes and symbols
- D. Decimal system

III. Estimating Metric Quantities (length and mass)

- A. Length - meter
- B. Mass - kilogram
- C. Common examples
- D. Practice in estimating

IV. Derived Units of Length and Mass

A. Area
B. Volume
C. Force and density
D. Velocity
E. Estimating area and volume
F. Approximating force and density
G. Estimating velocity

V. Additional Metric Quantities and Units

A. Temperature
B. Time
C. Electrical units
D. Force and work
E. Pressure
F. Common examples
G. Approximating to English equivalents

VI. Conversion Factors

A. Conversion from English to metric
B. Exact conversion factors
C. Rule of thumb conversions
D. Applications
E. Practice converting

VII. Metric Measurements and Measurement Equipment

A. Length
   1. Meter sticks and rulers
   2. Metric vernier calipers
   3. Metric tools
   4. Yard stick
   5. English vernier calipers
   6. English tools
B. Volume
   1. Cubic decimeters
   2. Liter containers
   3. Graduated cylinders and beakers
   4. Quart container
   5. Measuring cups
C. Mass
   1. Metric mass sets
   2. Balances
   3. English weight set
D. Temperature
   1. Celsius (centigrade) thermometers
   2. Fahrenheit thermometers

NARRATIVE OUTLINE

Orientation to the Metric System

Purpose: To provide information that will assist in orienting individuals to the everyday use of the metric system of measurement.

Why Metric

- The United States is converting to the metric system because it's a simpler, more universally used system.
- There are only 7 base units in the International System of Metric Measurement compared to more than 50 in the inch-pound system.
- In the metric system, larger and smaller units are obtained by combining the appropriate prefix with a base unit.
- Multiples and submultiples of metric units are related by powers of 10, just like our system of money: $.01, $.10, $1.00, $10.00, etc.
- The simplicity of the system will make calculations easier. Decimals are easier to work with than fractions.
- It will simplify the teaching of measurement in mathematics by delaying the introduction of fractions and requiring fewer units of measurement to learn.
- You use a variety of measures every day of your life. You shop, work, cook, and relax using a familiar measurement system, but you are already making more frequent use of the metric system than you probably realize. Many things are already measured in metric units such as drug prescriptions, motorcycle cylinder capacities, photographic film, competition in the Olympic games and some brands of cigarettes.
- The conversion of pharmaceuticals began many years ago and is now nearing completion. Most hospitals have completed conversion on an internal basis.
- While shopping, you may have noticed that most products are labeled in both metric and customary units. For example, the 7-Up Bottling Company has begun to package its product in liter bottles. Incidentally, most people couldn't tell the difference in size between a liter and a quart container.

- The key to learning a new language is thinking in that language, instead of translating from the familiar to the new language. In the same way, the key to learning the metric system is thinking metric and avoiding, wherever possible, converting measurement from metric to inch-pound units.

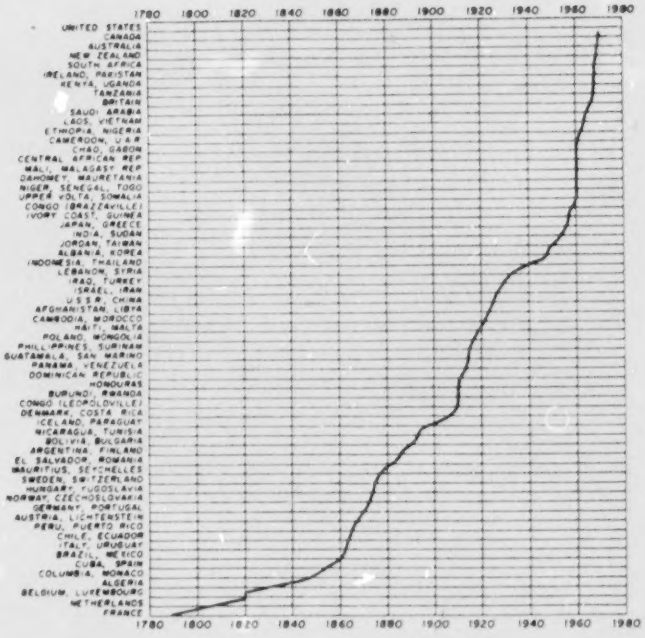
- How? By associating specific metric measurements with a visual experience or activity. For example, a meter is the length of a long step or a little more than the height of a doorknob. A nickel has a mass of about five grams, a dollar bill has a mass of about one gram. A kilogram of steak is a good serving for four adults.

- For most of us, there are only four important units to remember: for length, it is the meter; for volume, the liter (rhymes with meter); for mass (weight), the gram; and for temperature, degree Celsius. Except for temperature, these units combine with a few prefixes to give us the measurements most of us will encounter.

Metric Usage in the World

- More than 99 percent of the world's population live in metric countries. All the major industrialized nations have either already converted or are in the process of changing over to the metric system.

ADVANCE OF METRIC USAGE IN THE WORLD



- Since all these nations were either metric or committed to going metric, it was only a matter of time before the United States decided to convert in order to keep from damaging our position in international trade.

- Why are we converting to the metric system? First, the metric system is much simpler than the English system of feet, pounds, gallons, and degrees Fahrenheit. This should be reason enough. But there is another important reason for adopting the metric system. If we don't, soon we won't be able to talk to the rest of the world.

- The English language is the most widely spoken language in the world; it is the tongue of diplomacy, international commerce, and science. The prosperity of the English-speaking people has been so great that the world has imitated us in every area of life: our foods, our fashions, and our follies from pop music to soda pop. The principle reason for this position of world eminence has been our achievements in science and engineering. Half the units of science that honor a man have English names: Joule, Newton, Watt, Gilbert, Henry, Faraday, and Maxwell are examples. In fact, in the material achievements of science, English-speaking people have had no peers.

- If our language, currency, taste, and styles have become world standards, we would expect that our measurement system would be adopted too; that the world would measure with the foot, the pound, the ounce, the horsepower, and the square mile. But our fundamental language of science and engineering is so clumsy and archaic that other countries no longer use it.

- All the people of the world, except those in the United States (and a few small countries like Tonga and Liberia), now use the standard, elegant, streamlined language of the metric system. England, Australia, and New Zealand are currently in the middle of a 10-year program of conversion to the metric system. We have been left alone, and at great cost to ourselves.

Metric Usage in Industries

- Many industries are already largely metric. For example, a Bayer aspirin tablet is exactly one centimeter in diameter. Skis are sold or rented in metric sizes. The circumference of a common deodorant bottle is in metric measures.

- The cost to industry is one example. Since we buy and sell machinery and parts in the world market, many industries must maintain a double inventory of goods; one in the North American System of measurement and another in the metric system. Converting to the metric system will not only save the North American economy billions of dollars every year, but it will also help us remain competitive in world markets.

Metric Usage at Home

- The metric system will help us in other ways. One of these - and this is much more important than we might at first think - will be in simplifying the basic arithmetic and science taught in schools. As a conservative estimate, 15 percent of the time spent in elementary arithmetic is used to teach such tiresome skills as finding the least common denominator, reducing improper fractions, adding mixed numbers, and reducing fractions to their simplest terms. Complicated operations with fractions, which are primarily needed for arithmetic problems using feet and inches and pounds and ounces, can presumably be eliminated from the curriculum. The time spent in teaching just those skills may cost us well over a billion dollars a year. Of course, simple fractions will still be taught and used.

- Because it is based on ten, the Metric System of Measurement is easy to use. It has the same structure as our decimal number system with its place value based on ten. It is also the basis behind our system of money. Hence, teaching metrics will reinforce the work we already do with numbers and money.

- Computation in the metric system will involve decimals instead of more difficult fractions. Since decimals are easier to add, subtract, multiply and divide, computations should be more easily accomplished. Converting within the system will be done by multiplying or dividing by a power of ten. This will have the effect of simply shifting the decimal to the right or left.

- We are certainly not alone in our move to the metric system. Over 99 percent of the world's population live in countries either using the metric system or in the process of converting to it. With our commitment to officially begin the transition, signaled by the signing of the Metric Bill on December 23, 1975, the United States began the move to get into step with the rest of the world. We will no longer be a non-metric island in a metric sea.

The Metric System

Purpose: To help individuals become familiar with common units and terminology used in the metric system.

Basic Quantities

- The metric system is simpler and more logical than our customary tangle of inches, feet, yards, ounces, quarts, and pounds. It takes advantage of our decimal number system by relating multiples and submultiples of units by powers of ten.
- Our customary system is much more complicated. For instance, we divide feet by 12, or yards by 36 to get inches, and pounds by 16 to get ounces avoirdupois, or quarts by 32 to get liquid ounces.
- With metric units, computation may require no more effort than adding zeros or moving a decimal point.
- There are seven basic units in the modernized metric system. Of those seven, the following will be used most often:
  - meter - the unit for length
  - kilogram - the unit for mass (commonly called weight)
  - second - the unit for time
  - ampere - the unit for electric current
  - Celsius - the unit for temperature
- The other units are mole; for amount of substance, and candela, the unit for intensity of light. The liter, although not a basic metric unit, is commonly used to measure fluid volume.

Basic Units of Measurement

- The meter is approximately 3 1/3 feet for comparison purposes. The height of the average doorway in the home is 2 meters.
- The kilogram is about 2 1/2 pounds.
- The second is universally used, along with the minute, hour, and day.

- The ampere and other electrical units are not changed significantly from present usage.

- The temperature will be measured in °Celsius and is the same as the Centigrade scale. One °Celsius is approximately equal to two °Fahrenheit.

- The mole and candela are not used in everyday activities of the general public. Moles are used in chemical laboratory work and candelas are used in the lighting industry. (Light bulbs are now rated in lumens, a quantity directly related to the candela.)

Metric Prefixes and Symbols

- The only two important conditions for a measuring system are that the units be convenient and that they be consistent. Of all the measuring systems, metric units best satisfy these two conditions.

- Why is the metric system so much simpler? Because it uses the decimal system - it is based on multiples of ten.
If you're afraid you don't understand the decimal system, be assured that you do. You make use of it every day when you make change with money, since our money system is decimal. For example, a dime is one-tenth of a dollar, and a penny is one-hundredth of a dollar.

- With the metric system of prefixes and roots, the only conversions we need to make are from one size to another. There is a root for each physical quantity and a prefix for each significant size. To simplify things further, each prefix is a multiple of 10. For example, one common prefix is "kilo," meaning "a thousand times." This prefix added to the root "meter" (for the physical quantity of distance) produces "kilometer." A kilometer is a measurement of distance equal to 1000 meters. The prefix "kilo" added to the root "gram" (for the physical quantity of mass) produces "kilogram" which is equal to 1000 grams.

- The only prefixes you need to memorize are kilo-, centi-, and milli-. It will be enough if you familiarize yourself with the others.

- The symbols for the metric prefixes and units are handy to know. They're very simple as the table on page 11 shows.

METRIC SYMBOLS

Multiple	Prefix	Symbol	Unit	Symbol
1000000	mega-	M	meter	m
1000	kilo-	k	kilogram	kg
100	hecto-	h	second	s
0.1	deci-	d	ampere	A
0.01	centi-	c	Celsius	C
0.001	milli-	m		
0.000001	micro-	m		

Estimating Metric Quantities (length and mass)

Purpose: To provide a framework for estimating metric units of measurement using the "immersion" approach.

Length

- Let's begin with measurements of length. Presently, we use the inch, foot, yard and mile to denote length. From now on we will use the millimeter, centimeter, meter and kilometer.

- At first it might seem helpful to know that one meter is about 39 inches, or a little more than a yard. Thirty-nine inches can be visualized in the mind. But if you find that a piece of property you wish to buy is 63 meters long, you will have to start calculating.

- Might it not just be simpler to learn - and get it deeply embedded in your mind - that a football field is about 90 meters long?

- That is the principle we shall use here. Instead of translating inches into centimeters or miles into kilometers, we are going to break right on through to the other side and learn the metrics alone.

- The immersion method asks us to bypass cumbersome calculations and establish metric reference points that will help us estimate metric measurements.

Common Examples of Length:

Football field	90 m (approximately)
Basketball player's height	2 m (approximately)
Boone, NC (elevation 3300 ft.)	1 km
Classic American Measurements	92-62-92 cm
Large paper clip	1x5 cm
Width of hand including thumb	10 cm
Left shoulder to tip of right hand	1 m
10 miles	16 km

Estimating

- The best way to develop a good sense of length is to actually measure different length objects with a centimeter or meter ruler. Estimate the length of the objects first. Some lengths that may be estimated include: 12 inch ruler, height of chair, size of room, automobile, length of stride, width of film, diameter of aspirin, length of new pencil, height of desk, distance from home to school or work, etc.

Mass

- Americans have always measured weight in terms of ounces and pounds. These were not the best terms, but they were the only ones we had. Ounces were easily confused with the volume measurement also called ounces. There were 32 ounces in a quart, but only 16 in a pound.

- Now we will be introduced to the gram and the kilogram. A gram, like an ounce, is a very tiny measurement; much smaller than the ounce in fact. An ounce of gold is the equivalent of about 28 grams of gold. A kilogram - which means 1000 grams, if you recall the prefixes - is about 2.2 pounds. A metric ton is 2205 pounds.

- A big man will weigh about 100 kilograms (220 pounds) and a small woman about 50 kilograms (110 pounds).

- A nickel weighs 5 grams. An ordinary flashlight battery weighs 100 grams. A quart of milk weighs about 1 kilogram.

- The best way to develop a good sense of weight (mass) is to actually lift different objects or weigh them on a metric scale. If a scale is not available, comparison may be necessary.

Common Examples of Mass

Nickel	5 grams
Quart of milk	1 kg
Flashlight battery (Size D)	100 grams
Six pack	2.5 kg
100 pounds	45 kg
150 pounds	68 kg
200 pounds	91 kg

Estimating

- Some items that might be estimated for mass include: your weight, book, and a gallon of water (choose others from references).

Derived Units of Length and Mass

Purpose: To define derived units of length and mass and to provide experience in estimating these units.

Derived Units

. Almost all other metric units are derived from the seven basic units. For example, area, volume, force, velocity, and density are all units derived from length, mass, and time.

Area

. In measuring area we use the square meter (not meter square). This is used for floor space, wall space, land plots, etc. The rules are the same as in our customary system - you multiply side by side. A special unit of area is used in measuring land called the hectare which is equivalent to a square 100 meters by 100 meters. It is an area two and one half times as big as an acre.

Volume

. In our measuring system the dry and liquid quarts are not the same.

. Metric measures for volume are much simpler, because one set of units is used for both the liquid and the dry measures. In the metric system the cubic centimeter, the cubic decimeter, and the cubic meter are used for measuring the volume of solids and liquids. The milliliter (1 cubic centimeter) and liter (1 cubic decimeter) are used for measuring liquids and the capacity of containers. A liter is a little larger than a quart and will be used to measure items such as gasoline, milk, strawberries and drinks. The gallon is about 4 liters.

Force and Density

. Force and density are units derived from mass. Weight is a force resulting from the downward pull of gravity on an object. Forces can also act in other directions. On the moon the weight of an object would change, its mass would remain the same. You can measure the mass of objects with an equal arm balance and the weight with a spring scale. The basic unit for density in the metric system is kilograms per cubic meter or grams per cubic centimeter.

DENSITIES OF SOME COMMON SUBSTANCES

Water	1.00 gm/cm^3
Ice	0.92
Mercury	13.6
Lead	11.34
Iron	7.5
Aluminum	2.7
Cork	0.25
Air	0.0013

Additional Metric Quantities and Units

Purpose: To define additional metric quantities and units that might be used in specific occupational fields and to provide experiences in approximating these quantities.

Temperature

. Temperature is the class of units for which most people have the best "feel". Everyone talks about the weather. We intuitively "know" what a 90 degree day or a 10 degree day feels like. And 98.6° is important to us all. Precise conversions to the Celsius scale are cumbersome. Fortunately it is easy to think Celsius.

Temperature	Reference Point
0	Freezes water
10	Cool day
20	Room temperature
30	Hot summer day
37	Normal body temperature
40	Quite sick
100	Boils water
150	Bakes cakes
200	Bakes potatoes
250	Broils steak
1000	Melts gold
3000	Melts iron

Time

- The metric unit of time is strictly the second. However, due to the universal use of minutes, hours, and days these terms will continue to be used. Example: kilometers per hour (Note that time does not have the decimal relationship between its major units.)

Electrical Units

- The terms and symbols for commonly used electrical units are not changed significantly from what they are presently. (The same applies to units of light). Electric power companies use the kilowatt (and kilowatt hour) as a measure of the power they supply their customers. Watts are used for measuring intermediate sized power, like that required to operate home appliances. Milliwatts and microwatts are used to measure the tiny power requirements in electronic equipment. All power will now be expressed in watts:

Boilers	Btu-per hour	now watts
Engines	Horsepower	now watts
Refrigerators	Tons	now watts
Electric Motors	Horsepower	now watts

- Frequency is now designated in hertz rather than cycles per second; however, the basic units remain the same (60 hertz = 60 cycles per second). The definitions, units and symbols for electrical current (amperes), potential (volts), and resistance (ohms) remain the same.

Force and Work

- Work, energy, and quantity of heat are given in joules, the effort required to exert a force of one newton through a distance of one meter.

Pressure

- Pressure is another quantity related to force. It is defined as force per unit area. Twenty-eight pounds of air in our automobile tires is the amount of air that is exerting 28 more pounds of force per square inch on the inside of the tire than the pressure of air on the outside of the tire. The metric unit for pressure will be newtons per square meter, or pascal, which is not nearly as much per unit as one psi. It would take nearly 200,000 pascals to inflate an ordinary automobile

tire. Another metric unit of pressure is the bar, which is equal to 100,000 pascals. The bar is favored for pressure measurements because it closely approximates one atmosphere of pressure (14.7 psi). Stresses used in specifying types of steel will use hectobars. (1 hectobar=100 bars)

Conversion Factors

Purpose: To provide conversion factors that give the approximate metric value of English units.

Conversion from English to Metric

- If you are really thinking metric, you'll have no reason to convert from metric to English units. In fact, you should avoid converting from the metric system in any case because it can hinder your thinking metric.

- However, since it is so much easier to think metric than it is to think inch or pound, there may be good reason to convert pounds to kilograms and inches to centimeters. The practice you get in converting from English to metric units can be a good learning aid.

EXACT CONVERSIONS
(Accurate to Four Significant Figures)

Symbol	When You Know	Multiply by	To Find	Symbol
in	inches	2.54	centimeters	cm
ft.	feet	0.3048	meters	m
yd.	yards	0.9144	meters	m
mi	miles	1.6093	kilometers	km
yd^2	square yards	0.8361	square meters	m^2
	acres	0.4047	hectares	ha
yds^3	cubic yards	0.7645	cubic meters	m^3
qt	quarts (lq)	0.9463	liters	l
oz	ounces (Avdp)	28.349	grams	g
lb	pounds (Avdp)	0.4536	kilograms	kg
°F	Fahrenheit temperature	5/9 (After subtracting 32)	Celsius temperature	°C

- The exact conversion factors are hard to remember; however, for most purposes approximate conversion factors will be accurate enough.

RULE OF THUMB CONVERSIONS

Basic Quantity	Unit of Measurement	Approximate Conversion
Length	centimeters	= 2 1/2 (inches)=30 (feet)
	meters	= 1/3 (feet)-10%=yards-10%
	kilometers	= miles + 60%
Area	hectare	= 40% (acres)
Volume	liter	= quarts-6%
Mass	kilograms	= 1/2 (pounds)-10% remaining
	grams	= 30 (ounces)-10%
Temperature	°Celsius	= 1/2 (°F)-15
Velocity	Kilometers per hour	= miles per hour + 60%

Metric Measurements

PURPOSE: To provide experience in using metric measurement equipment in the shop or laboratory

- Everyday use of the metric system will result in the practice of estimation to determine equivalents, except when in the shop or laboratory
- Experience in making metric measurements can be provided to orient the individual to a broad cross-section of simple metric measurement tools. The practice will provide experience in reading metric scales and units that should prove helpful to those in or entering many occupations
- The individual working in a specific occupation or industry using metrics will have to be able to use the particular metric tools of the trade. Practice should be provided in using the particular type tools required
- It may be helpful to assess the measurement training needs of individuals prior to conducting sessions on metric measurements
- Possible equipment aids are listed below along with a chart for assessing measurement training needs

Quantity	Equipment Aid	
	Metric	English
Length	Meter sticks and rulers Metric vernier calipers Metric tools	Yard stick English vernier calipers English tools
Volume	Liter containers and cubic decimeters Graduated cylinders and beakers	Quart container Measuring cups
Mass	Metric mass sets Balances	English weight sets
Temperature	Celsius (Centigrade) Thermometers	Fahrenheit thermometer

A METRIC EDUCATOR'S TOOLS*

- Library of reference materials
- Blackboard
- Flip chart and stand
- 35-mm slide projector
- 35-mm audio-visual projector
- 16-mm movie projector
- Posters
- Metric ruler
- Metric micrometer
- Metric scale
- Sample metric prints
- Conversion slide charts
- Instructor's training guides
- Study sheets and/or instruction booklets
- Work sheets
- Test sheets

IDENTIFYING THE NEEDS FOR METRIC TRAINING *
(A METRICATION CHECK LIST OF GENERAL MEASUREMENTS TO HELP ASSESS TRAINING NEEDS OF INDIVIDUALS)

Category of Students (by Job Title or Curriculum)	No. in category	MEASUREMENT UNITS USED IN NORMAL WORK ACTIVITY															Remarks
		Length	Area	Volume	Weight	Temperature	Pressure	Stress	Density	Force	Velocity	Power	Energy	Luminance	Current	Money	

* From "Managers Plan and Train for a Metric Future" Iron Age, May 5, 1975 p 43-47.

SUGGESTED RESOURCES

Orientation to Metric System

Mathematics Division. Moving to Metric. Metric Resource Center, N.C. Department of Public Instruction, Raleigh, NC 27611. 17 pages. *

Delaware State Department of Public Instruction. Everything You Wanted to Know About the Metric System: But Were Afraid to Ask. Metric Resource Center, N.C. Department of Public Instruction, Raleigh, NC 27611. 4 pages. *

National Bureau of Standards. Brief History of Measurement Systems: With a Chart of the Modernized Metric System. Superintendent of Documents, U. S. Government Printing Office, Washington DC 20402.*

Consumer Information Services. An Educator's Guide to Teaching Metrication. D/J03, Sears, Roebuck and Company, Chicago, IL 60684. 8 pages, 1974.*

Aron, Mike. "Your Final and Complete Metric and Celsius Lesson" in Holiday Inn Companion. September 1976. pages 15-19, $1.00.*

National Bureau of Standards. A Metric America (Publication 345). Superintendent of Documents, U. S. Government Printing Office, Washington, DC 20402. 170 pages, 1971, $2.25.

_____. Measuring Systems and Standards Organizations. American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018.

Perica, Lou. Metric Education Guide for Employee Training. American National Metric Council, 1625 Mass. Ave., NW, Washington, DC 20036. 1975, $6.00.

_____. Going Metric. Channing L. Bete Company, Inc., Greenfield, MA.

Armbruster, F.O. Think Metrics: A Basic Guide to the Metric System. Troubador Press, 126 Folsom St., San Francisco, CA 94105. $1.50.

National Bureau of Standards. Some References on Metric Information (Publication 389). Superintendent of Documents, U. S. Government Printing Office, Washington, DC 20402. 1973, $0.25.

Donovan, Frank. Let's Go Metric. Weybright and Talley. 750 Third Ave., New York, NY 10017. 1974.

_____. Preparing Now to Go Metric. The Research Institute of America, Inc., Department III, Mt. Kisco, NY 10549. 40 pages, 1974, $4.00.

National Bureau of Standards. What About Metric? Superintendent of Documents, U. S. Government Printing Office, Washington, DC 20402. $1.10.

Deming, Richard. Metric Power: Why and How We are Going Metric. Thomas Nelson Inc., Nashville, TN. 1974, $6.00.

Burton, William K. Measuring Systems and Standards Organizations. American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018. $1.25.

The Metric System

Sellers, Robert C. Basic Training Guide to the New Metrics and SI Units. Robert C. Sellers and Associates, Inc., Floral Park, New York 11002. 60 pages, 1972, $2.00. *

_____. Metrication Handbook. J. J. Keller & Associates, Inc., 145 West Wisconsin Ave., Neenah WI 54596. $10.00.

Gilbert, T.F. and Gilbert, M.B. Thinking Metric: Self Teaching Guide. John Wiley & Sons, Inc., New York, NY. 142 pages, 1973, $3.00.

National Bureau of Standards. Brief History of Measurement Systems With a Chart of the Modernized Metric System. Superintendent of Documents, U. S. Government Printing Office, Washington, DC 20402. 4 pages, 1974, $0.25.

Prescott, Elizabeth. Practical Metrics. Willow House Publishers, 111 N. San Joaquin Street, Stockton, CA 95202. $2.50.

Cherrington. Metric Workshop for Teachers. Willow House Publishers, 111 N. San Joaquin Street, Stockton, CA 95202. $2.50.

Massey, Opal. Metrics for Home Use. Willow House Publishers, 111 N. San Joaquin Street, Stockton, CA 95202. $2.50.

Armbruster, F. O. Think Metrics: A Basic Guide to the Metric System. Troubador Press, 126 Folsom Street, San Francisco, CA 94105. 1974, $1.50.

_____. USOE Sponsored Project No. V257006 Grant No. O EG-0-72-1868. Center for Metric Education, Western Michigan University. 1972.

Donovan, Frank. Prepare Now for a Metric Future. Weybright and Talley, 750 Third Ave., New York, NY 10017. $9.00.

Schimizzi, Ned V. Mastering the Metric System. Mentor Books, New York, NY 10019. 1975, $1.50.

Jones, M.J. B. A Guide to Metrication. Pergamon Press, New York, NY. 1969.

Fearon, Arthur D. Everyday Metrics. Willow House Publishers, 111 N. San Joaquin Street, Stockton, CA 95202. $2.50.

Estimating Metric Quantities

_____. Metric Cube (A Metric Aid) Mathematics Division State Department of Public Instruction Raleigh, NC 27611.

_____. A Metric America (16mm Film). Aims Instructional Media Services, Inc., P.O. Box 1010, Hollywood, CA 90028. $240.00.

Sellers, Robert C. Basic Training Guide to the New Metrics and SI Units. Robert C. Sellers and Associates, Inc., Floral Park, New York 11002. 60 pages, 1972, $2.00.

_____. Metrication Handbook. J.J. Keller & Associates, Inc., 145 West Wisconsin Avenue, Neenah, Wisconsin 54956. $10.00.

Kelly, Gerald W. Metric System Simplified. Sterling Publishing, Company., Inc., 419 Park Ave. South, New York, NY 10016. 1974.

Cherrington, Don. Metric Workshop for Teachers. Willow House Publishers, 111 N. San Joaquin Street, Stockton, CA 95202. $2.50.

Massey, Opal. Metrics for Home Use. Willow House Publishers, 111 N. San Joaquin Street, Stockton, CA 95202. $2.50.

Prescott, Elizabeth. Practical Metrics. Willow House Publications, 111 N. San Joaquin Street, Stockton, CA 95202. $2.50.

Donovan, Frank. Prepare Now for a Metric Future. Weybright and Talley, 750 Third Ave., New York, NY 10017. $9.00.

Derived Units

Sellers, Robert C. Basic Training Guide to the New Metrics. Robert C. Sellers and Associates, Inc., Floral Park, NY 11002. 1972, $2.00.

Sellers, Robert C. Reference Handbook for the Proper Usage of Metric SI in Science and Engineering. Robert C. Sellers and Associates, Inc., Floral Park, NY 11002. 1974, $2.00.

Schimizzi, Ned V. Mastering the Metric System. Mentor Books, New York, NY 10019. 1975, $1.50.

Additional Metric Quantities and Units

_____. Metric Units of Measure and Style Guide. U.S. Metric Assoication, Inc., Sugarloaf Star Rt., Boulder, Colorado 80302.

Sellers, Robert C. Reference Handbook for the Proper Usage of Metric SI in Science and Engineering. Robert C. Sellers and Associates, Inc., Floral Park, NY 11002. 1974, $2.00.

Sellers, Robert C. Basic Training Guide to the New Metrics and SI Units. Robert C. Sellers and Associates, Inc., Floral Park, NY 11002.

Conversion Factors

Machinery's Handbook Editors. Metric Conversion Tables and Factors. Industrial Press Inc., 200 Madison Ave., New York, NY 10016.

Kelly, Gerald W. Metric System Simplified. Sterling Publishing Co., Inc., 419 Park Ave. South, New York, NY 10016. 1974.

_____. Official Metric System. J. J. Keller and Associates. Inc., Neenah, WI 54956. 1975, $1.00.

Metric Practice Guide. American National Standard E210.1. 1430 Broadway, New York, NY 10018.

_____. Engineer's Guide to Modern International Units of Measurement. Elliott Company, Jeannette, PA 15644.

Metric Measurement

Smart, James. Metric Math: The Modernized Metric System. Brooks/ Cole Publishing Company, 540 Abrego Street, Monterey, CA 95202. 1974, $2.50.

Schell, Frank R. Practical Problems in Mathematics. Delmar Publishers, Albany, NY 12205. 1975.

Cherrington. Metric Workshop for Teachers. Willow House Publishers, 111 N. San Joaquin Street, Stockton, CA 95202. $2.50.

Massey, Opal. Metrics for Home Use. Willow House Publishers. 111 N. San Joaquin Street, Stockton, CA 95202. $2.50.

Prescott, Elizabeth. Practical Metrics. Willow House Publishers. 111 N. San Joaquin Street, Stockton, CA 95202. $2.50.

Kempf, A.F. and Richards, T.J. Using the Metric System. Laidlaw Brothers Publishing Company, River Forest, IL. 1973.

Helgren, Fred J. Metric Supplement to Science and Mathematics. Ideal School Supply Company, 11000 Lavergne Avenue, Oaklawn, IL. 60453. 1973.

Johnson, H. N. and Roberson, M. J. Experiences in the Metric System. Amidon and Associates, Inc., 4329 Nicollet Avenue South, Minneapolis, MN 55409. 1974.

Frost, Helgren, and Sokol. Metric Handbook for Hospitals. U.S. Metric Association, Inc., Sugarloaf Star Route, Boulder, Colorado 80302. 1975.

Additional Resources

_____. Metric Education: An Annotated Bibliography for Vocational, Technical, and Adult Education (OEC-0-74-9335). Center for Vocational Education, Ohio State University, 1960 Kenny Road, Columbus, OH 43210.

Koch, Annalise K. Metrication: A Selective Bibliography. Technical Information Center, North Carolina State University, P.O. Box 5007, Raleigh, NC 27607.

_____. Instructional Materials for Metric Education: A Selected Annotated Bibliography. Division of Mathematics, North Carolina Department of Public Instruction, Raleigh, NC 27611. 1975.

_____. USOE Sponsored Project No. V 257006 Grant No. OEG-0-72-1868. Center for Metric Education, Western Michigan University.

National Bureau of Standards. A Metric America: A Decision Whose Time Has Come NBS SP (345). Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. $2.25.

Sub-studies:

NBS SP 345-1	International Standards	$1.25
NBS SP 345-2	Federal Government-Civil Agencies	2.25
NBS SP 345-3	Commercial Weights & Measures	1.00
NBS SP 345-4	The Manufacturing Industry	1.25
NBS SP 345-5	Non Manufacturing Business	1.50
NBS SP 345-6	Education	1.75
NBS SP 345-7	The Consumer	1.25
NBS SP 345-8	International Trade	1.50
NBS SP 345-9	Department of Defense	1.25
NBS SP 345-10	A History of the Metric System Controversy in the United States	2.25
NBS SP 345-11	Engineering Standards	2.00
NBS SP 345-12	Testimony of Nationally Representative Groups	1.50

Sellers, Robert C. Metric Transition for Managers. Robert C. Sellers and Associates, Inc., Floral Park, NY 11002. 1975, $20.00. *

_____. A Bibliography of Metric Standards. American National Standards Institute, 1430 Broadway, New York, NY 10018.

_____. SI Units and Recommendations for the Use of Their Multiples and of Certain Other Units. American National Standards Institute, 1430 Broadway, New York, NY 10018.

_____. Metric Conversion in Engineering and Manufacturing. American National Metric Council, 1625 Massachusetts Ave. NW., Washington, DC 20036.

_____. Metrication Handbook. JJ Keller and Associates, Neenah, WI 54956. $4.00.

*Resource used in compiling the narrative outline.

Agencies and Organizations

. North Carolina Metric Resource Center
North Carolina State Department of Public Instruction
620 North West Street
Raleigh, NC 27611

Library of Metric Materials, "Metric Cube", Posters, Etc.

. Industrial Extension Service
North Carolina State University
P.O. Box 5506
Raleigh, NC 27607

Short Courses for Industry, Films, Transparencies

. Management Development Program
Industrial Services Division
Department of Community Colleges
Raleigh, NC 27611

MDP Short Course-Metrication for Supervisors

. Metric Information Office
National Bureau of Standards
Department of Commerce
Washington, DC 20234

Publications, Posters, Flyers, Aids, Etc.

- American National Metric Council
  1625 Massachusetts Avenue, N.W.
  Washington, DC 20036

  Provides Assistance Through Coordination, Planning and Information Services to Business, Industry, Education, Labor and Government

- U.S. Metric Association, Inc.
  Sugarloaf Star Route
  Boulder, CO. 80302

- American National Standards Institute, Inc.
  1430 Broadway
  New York, NY 10018

All You Will Need to Know About Metric

(For Your Everyday Life)

10

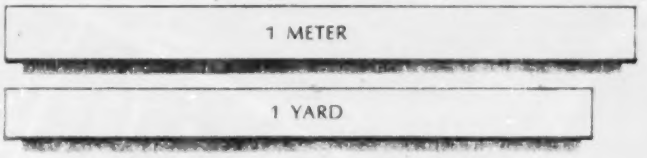
Metric is based on Decimal system

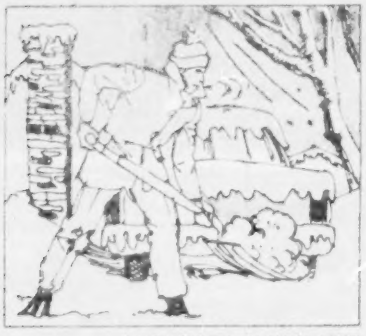
The metric system is simple to learn. For use in your everyday life you will need to know only ten units. You will also need to get used to a few new temperatures. Of course, there are other units which most persons will not need to learn. There are even some metric units with which you are already familiar: those for time and electricity are the same as you use now.

BASIC UNITS

METER: a little longer than a yard (about 1.1 yards)
LITER: a little larger than a quart (about 1.06 quarts)
GRAM: about the weight of a paper clip

(comparative sizes are shown)





25 DEGREES FAHRENHEIT

25 DEGREES CELSIUS

COMMON PREFIXES

(to be used with basic units)

Milli: one-thousandth (0.001)
Centi: one-hundredth (0.01)
Kilo: one-thousand times (1000)

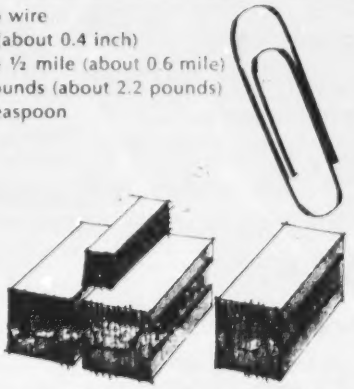
For example:
1000 millimeters = 1 meter
100 centimeters = 1 meter
1000 meters = 1 kilometer

1 LITER

1 QUART

OTHER COMMONLY USED UNITS

Millimeter:	0.001 meter	diameter of paper clip wire
Centimeter:	0.01 meter	width of a paper clip (about 0.4 inch)
Kilometer:	1000 meters	somewhat further than ½ mile (about 0.6 mile)
Kilogram:	1000 grams	a little more than 2 pounds (about 2.2 pounds)
Milliliter:	0.001 liter	five of them make a teaspoon



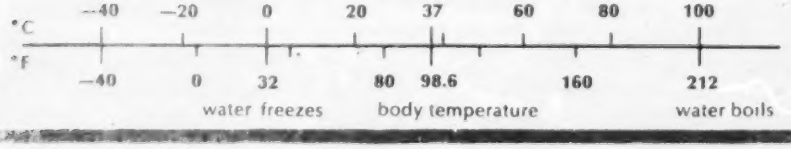
1 KILOGRAM 1 POUND

OTHER USEFUL UNITS

Hectare: about 2½ acres
Tonne: about one ton

TEMPERATURE

degrees Celsius are used



For more information, write to: Metric Information Office, National Bureau of Standards
Washington, D.C. 20234

Note This chart may be reproduced

31